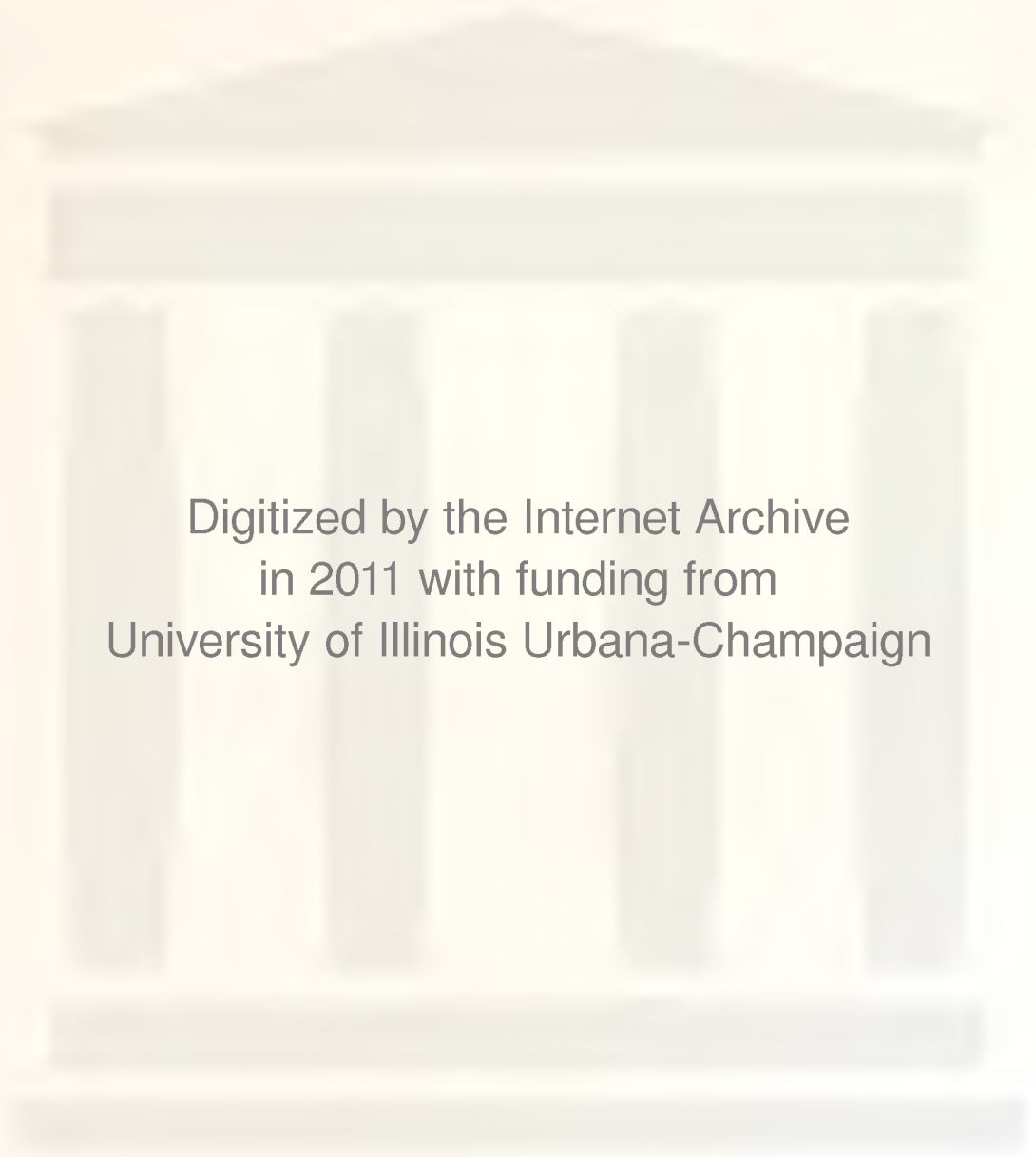

Faculty Working Papers

ANNUAL BIRTHS UNDER CONDITIONS OF RAPID CHANGES IN CONTRACEPTIVE TECHNOLOGY

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#560

College of Commerce and Business Administration
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Summary:

This study focuses upon the annual number of births over the interval 1950-1974. Three important factors are isolated which are associated with births; these are, income, population size, and expenditures on birth control technology. Other variables inserted into the estimating equations were found to add little by way of forecasting improvements.

Changes in contraceptive technology seem to be important in determining births. The increase in the power of the technology has made it feasible for households to more realistically examine children in the framework postulated by the Chicago School, Leibenstein, or Easterlin.

Annual Births Under Conditions of Rapid Changes in Contraceptive Technology

Walter J. Primeaux, Jr.
and
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The American baby boom following World War II is history, and attention focuses largely upon the baby dearth of the 1960s and 1970s. Estimating annual births following World War II would not have been too difficult if one could have found the set of factors which identified the turning points. Following the end of WWII, births increased from 2,858,000 in 1945 to 4,268,000 in 1961. By 1973, births were 3,137,000 down 26 percent from the 1961 peak.

Conflicting hypotheses have been advanced to explain fertility behavior. A leading theory of fertility which can be labeled the Chicago Model postulates that children are consumer durable goods from which parents consume services.[1] Parents are rational in the Chicago Model calculating the cost and benefits of births within the household income and savings framework. Cain has estimated the cost of raising a child, including the important factor of time foregone, at $31,000.[2]

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[1]Papers commonly associated with the Chicago School include Gary S. Becker, "An Economic Analysis of Fertility," in National Bureau of Economic Research, Demographic and Economic Change in Developed Countries, (Princeton, 1960); Becker's "A Theory of the Allocation of Time," Economic Journal 75 229 September 1965, pp. 493-517 and Paul T. Schulz, "Explanation of Birth Rates Changes Over Space and Time: A Study in Taiwan," Journal of Political Economy 812 Part II March/April 1973 pp. S238-274, and Theodore W. Schulz, "The Value of Children: An Economic Perspective," Journal of Political Economy, S12 Part II March/April, pp. S2-13.

[2]Inflation has probably raised this figure substantially. See Glen G. Cain, "Issues in the Economics of a Population Policy for the United States," American Economic Review 61, No. 2 (May 1971), p. 412.

Under the Chicago Model, children are postulated as subject to diminishing marginal utilities similar to any other consumer good.

In contrast to the Chicago Model, Leibenstein[3] assumes that children represent commitment goods. Children are not subject to diminishing marginal utility in the Leibenstein framework but rather to increasing marginal utility up to some unspecified level beyond which traditional diminishing marginal utility sets in. In the Leibenstein framework, children represent a commitment upon the part of parents.

A third and somewhat different view of fertility was formulated by Easterlin. Easterlin notes that relative income is an important fertility determinant. Rising relative income leads to higher fertility levels for households consider themselves better off or likely to be better off in the near future.[4]

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[3]Harvey Leibenstein, "An Interpretation of the Economic Theory of Fertility: Promising Path or Blind Alley?" Journal of Economic Literature, 12, 2 (June 1974) 457-479. "On the Economic Theory of Fertility: A Reply to Keeley" Journal of Economic Literature 13, 2 (June 1975) pp. 469-472. Michael C. Keeley, "A Comment on An Interpretation of the Economic Theory of Fertility," Journal of Economic Literature 13, 2 (June 1975), pp. 461-467.

[4]Richard A. Easterlin, "Economic-Demographic Interaction and Long Swing in Economic Growth," American Economic Review 56, No. 5 (December 1966), pp. 1063-1104, and "On the Relation of Economic Factors to Recent and Projected Fertility Changes," Demography 3, No. 1 (1966), pp. 131-153. Also note Ronald Lee, "The Formal Dynamics of Controlled Populations and the Echo, The Boom and the Bust," Demography 11, No. 4 (November 1974), pp. 563-586, and "Target Fertility, Contraception, and Aggregate Rates: Toward a Formal Synthesis," Demography 14, No. 4 (November 1977), pp. 455-480, and Michael L. Wachter, "A Time-Series Fertility Equation: The Potential for a Baby Boom in the 1980s*," International Economic Review 16, No. 3 (October 1975), pp. 609-624.

Gregory et. al.[5] has developed a model which takes into cognizance such factors as permanent income, female participation rates, infant mortality, and other socio-economic factors.

This study focuses upon the annual number of births over the interval 1950 to 1974. The Chicago School, Leibenstein, and Easterlin theories of fertility are examined within the concepts of economic, demographic, and social factors which influence births. The model incorporates the impact of such important changes as new birth control technology insofar as it has influenced births. Changes in contraceptive technology have been dramatic over this interval 1950 - 1974. Expenditures on birth control pills alone increased from virtually nil in 1962 to $135 million in 1974. Births peaked prior to the introduction of the pill. Despite the growing female cohort aged 20 - 29, a prime fertility period, births continued to decline. Contraceptive technology is now sufficiently advanced as to enable a more precise test of the conflicting hypotheses for it has substantially reduced unanticipated or unwanted pregnancies. For convenience in following the discussion the paper is divided into two parts; an examination of the model followed by a section presenting the empirical findings.

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[5]Paul R. Gregory, John M. Campbell, and Benjamin S. Cheng, "A Simultaneous Equation Model of Birth Rates in the United States," Review of Economics and Statistics 374-380, U.S. Dept. of Commerce Bureau of Census, Pop. Est & Projections, Series P-25, No. 727, July 1978. U. S. Dept. HEW Vital Statistics Report First Natality Statistics 1977, Vol. 27, No. 11.

MODEL

The conceptual framework of the model rests upon the assumption that economic, demographic, and social factors influence births. The model further assumes that changes in contraceptive technology influences births. For convenience, these factors may be summarized as follows:

$$\beta = f(E,D,S)$$

where β represents annual births, E a set of economic determinants/predictors, D a set of demographic determinants/predictors, and S a set of social determinants/predictors. The model was estimated using a second-order Cochrane-Orcutt procedure with the equation in the general form of:[6]

$$Y_t - \rho_2 Y_{t-2} = \beta_1(1 - \rho_2) + \beta_2 \rho_2 X_{2_{t-2}} + \ldots + \beta_n(X_{n_t} - \rho_2 X_{n_{t-2}})$$

The procedure requires calculations of a series of iterations which produce first and second order estimates of ρ. The estimated value of ρ is used in second differencing the regression equation. The model was constructed following the principle of Occam's razor, using data from 1950 through 1974.[7]

Economic variables identified as potentially influencing births include income, the female labor force and the female labor force participation rate. Demographic or demographically associated variables

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[6]Robert S. Pindyck and Daniel L. Rubenfeld, Econometric Models and Economic Forecasts, 1976, pp. 111-112.

[7]While 1975, 1976 and 1977 data were available, these years were omitted from the equations in order to test the equations against three data points not included.

TABLE 1

VARIABLES AND SOURCES OF DATA

Variables	Definition	Source of Data
	Dependent Variables	
Births		
BTTL	Births - total population	U.S. Department of Commerce, Bureau of the Census, Vital Statistics of the U.S. 1950-1977.
	Independent Variables	
College Degree Variables		
GS-TTL	Degrees - bachelor - total	Earned degrees conferred as given by the U.S. Department of Commerce, Bureau of the Census, Statistical Abstract of the United States, various issues.
GS-T-F	Degrees - bachelor - female	
Population Variables		
OP-TTL	Population - total, resident civilian	U.S. Department of Commerce, Bureau of the Census, Current Population Reports, Series P-25, Nos. 310, 519, 614.
ASTE	Fashion in births average of two years, lagged one year	Source: Same as POP-TTL.
F 15-19, 20-4, 25-29, 30-4, 35-44, etc.	Female population - total by age, 15-19, 20-24, 25-29, 30-34, 35-44, etc.	Source: Same as POP-TTL
Other Variables		
-LBR	Female labor force	U.S. Department of Labor, Bureau of Labor Statistics, Employment and Earnings, various issues; and Employment and Training Report of the President 1977.
-LFPR	Female labor force participation rate	
	Real disposable personal income	U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, various issues.
/P	Real disposable personal income, per capita	
ILL	Birth control pill dollar sales	U.S. Department of Commerce, Social and Economic Statistics Administration, Bureau of the Census, Industry Division, Current Industrial Reports, Pharmaceutical Preparations, Except Biologicals, service MA-28, various years.
AR	War variable, dummy variable	See text.
ARRIAGE	Number of marriages	U.S. Department of Commerce, Bureau of the Census, Vital Statistics of the United States, 1950-1977.

considered important in determining births included population size, marriage, and contraceptive technology. War and the number of college degrees granted were also inserted to measure their probable impact upon the number of births. "Fashion" in births was inserted as a social indicator. These variables are summarized in Table 1. A brief discussion of the rationale for including the variables precedes an examination of their estimating power.

Income is a variable which is commonly associated with births. Easterlin's relative income hypothesis would seem to link income and births in a positive sense. Higher incomes are associated with more births in the Easterlin framework on the assumption that they can now afford children.

The sign attached to the income coefficient in considering the Chicago School's views and Leibenstein's views on birth, however, is not so apparent. A positive coefficient could be interpreted as consistent with the indication that higher levels of income encourage increased consumption of all goods, including children (more commitments). On the other hand, a substitution effect will obviously come into consideration in the form of a negative association between income and births. Within the Chicago and Leibenstein's framework, a negative income coefficient could be intrepreted as providing support for an overwhelming substitution effect since children are relatively more expensive and absorb household time (consume more nonchildren goods). A negative income coefficient would be consistent with rising female participation rates which substantially boost the opportunity costs of

children.[8]

Contributing to increased opportunity costs of birth is the rising number of females entering the labor force during the past 15 years. In 1950, for instance, 34 percent of the female cohort 25-34 was recorded as in the labor force. There was little change in the participation rate as recently as 1963 when 36.4 percent of the cohort, up about 2.5 percentage points from the 1950 level, was in the labor force. Beginning in 1964, however, female participation rates began to rise rather dramatically (as births began to diminish). By 1970, the participation rate for the cohort 25-34 was 45 percent, and in 1974, 52.4 percent. Over the 25-year period, 1950 through 1974, female participation rates for this cohort increased over 50 percent. Most of the increase, however, developed after 1965. Similar increases were recorded among females 20-24. One would anticipate a negative association between births and the proportion of females in the labor force, since these women might be more inclined to postpone or reduce births. On the other hand, a strong case could be made for a positive association in the sense that female participation raises household income and thereby enables the household to afford more children. These conflicting forces, however, make it difficult to determine this coefficient's sign.

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[8]These tests are approximations since real disposable personal income is only a crude proxy for permanent income (Chicago) and relative income (Easterlin). Births rather than birth rates were used as a fertility measure. While there are differences in the rates of change between birth rates and births, these measures generally move in the same direction.

Size of the population is among the more important demographic factors influencing births. A positive association between population size and births is obvious. The models constructed below use several variants of population size. The variant which proved most successful was total civilian population.[9]

Marriage is another demographic factor which was inserted into the model to make allowance for its impact upon births. One would expect an increase in the number of marriages to be associated with an increase in births. This association, however, may be weakened by changes in birth control technology.

Contraceptive technology is an important variable which must be taken into account when examining births. There have been dramatic changes in birth control techniques since 1950, and these changes have influenced births. Important changes in contraceptive technology include development and application of the pill, intrauterine devices, vasectomies, and improved contraceptive foams. It is difficult to obtain quantitative data on the use of these methods, consequently a surrogate measure of contraceptive technology changes, the dollar- volume sales of pills, was used. Data were available from 1963 through 1976.[10] This index was converted into a real dollar volume of pills sold by using a deflator for pharmaceutical hormone products. The deflator had little impact, however, since price changes for this

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[9]Variants of population were tried, such as the female population 15-44, or 15-45, or the total population including military. None of these variables worked as well as total civilian population.

[10]Prior to 1963 pill sales were negligible. See Chemical Week 106, No. 13, (April 1, 1970).

commodity were negligible between 1963 and 1975.[11].

College degrees were also used as a variable in estimating births. It was hypothesized that an increase in the number of degrees may lead to a decrease in the number of births, since females will likely be oriented toward working outside the home. On the other hand, degrees may influence births in a positive manner, since the number of degrees will increase household incomes and thereby increase the demand for children. These conflicting forces make it difficult to assign a sign to this variable.

Births are also influenced by prevailing social trends. If it is "fashionable" or desirable to have a large (small) family, this attitude will likely show up in the number of births. To measure "fashion," a lagged birth variable was created. This variable was constructed by averaging births of two previous years to measure trends or fashions in births.

Finally, it is possible that the number of births could be influenced by war. War was inserted as a dummy variable, with the years 1950 through 1953 and 1965 through 1970 being assigned the value of 1, the remaining years, the value of 2.

EMPIRICAL RESULTS

Several equations were estimated using the variables cited in Table 1. Following Occam's razor, the best estimate of births was derived using three explanatory variables; income, population size, and

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[11]It was not possible to obtain a data series on the quantity of pills sold. Since there was little price change from 1963-1975, dollar-volume pill sales was probably as good an indicator as quantity. Time series data for other contraceptive devices were not available.

pill sales (Table 2). All three coefficients were statistically significant and the DW statistic (DW = 1.93) indicated that serial correlation did not bias the results (Table 2).

Population was positively associated with births as expected while income and birth control expenditures were negatively related with birth. The negative association between births and income (real disposable personal income) can be interpreted as providing support for the Chicago School and Leibenstein's views. The rising opportunity cost of children is attributed to a larger proportion of females employed in the monetary sector of the economy. A negative coefficient seems to indicate that the substitution effect predicted by the Chicago School predominates. The coefficient could also be interpreted as lending support to Leibenstein's views since children are commitment goods. Fewer households may be willing to accept the commitment of children given the tendency for female participation rates to rise as they have over the past two decades.

TABLE 2

REGRESSION COEFFICIENTS AND STANDARD ERRORS#

Y (Income)	P Population	Pill Birth Control	Constant
-.48401	2.7543	-.00461	937.46
(.10923)	(0.6050)	(.00138)	
$\bar{R}^2$ = 0.886	SEE = 71.1	DW = 1.93	N = 23

#Income in $100 million units, population in 100 thousand units, and pill sales in $1,000 units.

The pill variable was statistically significant (at the .005 level or beyond) and negatively associated with births, as expected. A $100 million expenditure on pills in any year was associated with a reduction in births of 461,000. There seems to be little doubt that changes in contraceptive technology have reduced the number of births. During 1974, for instance, expenditures on pills amounted to $135 million. This change in contraceptive technology has enabled households to more carefully determine fertility and to more nearly equate desired and actual fertility. According to the model, births were 622,000 lower than they would have been had the pill been unavailable and no substitute birth control methods been possible.

Testing the Results. The results of our equation were used to test against actual births in 1975, 1976, and 1977, and are summarized in Table 3. (The equation contains information from 1950 through 1974). The equation predicted 1975 and 1976 births with low errors. Predicted values for 1975 and 1976 were within 1.5% (average) of actual births. The error increased to 6.8% in 1977 as births increased by 150,000 over the 1976 level.[12] The model provides a simple and accurate means of forecasting annual births taking into account economic, demographic, and social factors and changing contraceptive technology.

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[12]Based upon preliminary pill data. As data for 1978 becomes available, 1975, 1976, and 1977 should be entered into the equation and the coefficient reestimated.

TABLE 3

ESTIMATING ACCURACY OF THE MODEL, 1975-76

Year	Actual Births	Estimated Births	Error	Relative Error
1975	3,150,000	3,234,000	+84,000	2.6%
1976	3,165,000	3,176,000	+11,000	0.4%
1977	3,326,000	3,100,000	-226,000	6.8%
		Mean Error		3.3%

Source: Calculated from table in Table 2, using 1975, 1976 and 1977 data points.

CONCLUSIONS

This paper has isolated three important factors which are associated with births, income, population size, and expenditures on birth control technology. Several additional variables were examined and inserted into the estimating equations but were found to add little in the way of forecasting improvement or in determining the major variables associated with births. Following Occam's Razor, the best estimate of births using the simplest model is presented here.

The model has both forecasting and explanatory implications. For forecasting purpose the model provides a simple and concise and relatively accurate forecasting instrument. The effects of rising income levels and additional expenditures for contraceptives can be quantified and compared with the impact of a larger population. Data for forecasting births over a short run period are readily available.

From an explanatory point of view, the model suggests that rising income levels were associated with fewer births. This finding would appear to lend support to the Chicago and Leibenstein's views of fertility if the substitution effect is assumed to predominate. Higher levels of real disposable personal income may be associated with an increased opportunity cost of children. While the negative coefficient is consistent with one possible interpretation of the Chicago School's views it is also consistent with Leibenstein's notion that children represent commitment goods in terms of time and money.

Changes in contraceptive technology seem to be important in determining births. The increase in the power of the technology has made it feasible for households to more realistically examine children in the framework postulated by the Chicago School, Leibenstein, or Easterlin.